# Drill Rig Emissions

**Assumptions:**

| | | |
|---|---|---|
| Hours of Operation | 600 | hours/core hole (Proposed Action - 25 days at 24 hours a day) |
| Development Rate | 4 | core holes per year (Proposed Action) |
| Load Factor | 0.4 | (Assumed typical value) |
| Dril Rig Horsepower | 1,500 | hp |
| Diesel Fuel Sulfur Content | 0.0005 | percent (EPA standard value) |

**Equations:**

Emission factor conversion: 1b/hp-hr = AP-42 emission factor (lb/MMbtu) * 7500 Average BTU/hp-hr / 1,000,000

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (lb/hp-hr)} * \text{Rated Horsepower (hp)} * \text{Operating Hours (hrs)} * \text{Load Factor (Dimensionless)}}{\text{2000 (lb/tons)}}$$

SO2 E. Factor (lb/hp-hr) = Fuel sulfur content * 0.00809

| Species | Drill Rig Emissions (Tier II) | | | |
|---|---|---|---|---|
| | E. Factor | Emissions | | |
| | | Per Well | Per Well | Total |
| | (lb/hp-hr) | (lb/hr) | (tons/yr) | (tons/yr) |
| *Criteria Pollutants & VOC* | | | | |
| **NOx** [a] | 0.0152 | 9.12 | 2.74 | 10.94 |
| **CO** [a] | 5.73E-03 | 3.44 | 1.03 | 4.13 |
| **VOC** [a] | 2.20E-03 | 1.32 | 0.396 | 1.58 |
| **$PM_{10}$** [a] | 4.00E-04 | 0.24 | 0.072 | 0.288 |
| **$PM_{2.5}$** [b] | 4.00E-04 | 0.24 | 0.072 | 0.288 |
| **$SO_2$** [b] | 4.05E-06 | 2.43E-03 | 7.28E-04 | 2.91E-03 |
| *Hazardous Air Pollutants* | | | | |
| **Benzene** [d] | 5.82E-06 | 3.49E-03 | 1.05E-03 | 4.19E-03 |
| **Toluene** [d] | 2.11E-06 | 1.26E-03 | 3.79E-04 | 1.52E-03 |
| **Xylenes** [d] | 1.45E-06 | 8.69E-04 | 2.61E-04 | 1.04E-03 |
| **Formaldehyde** [d] | 5.92E-07 | 3.55E-04 | 1.07E-04 | 4.26E-04 |
| **Acetaldehyde** [d] | 1.89E-07 | 1.13E-04 | 3.40E-05 | 1.36E-04 |
| **Acrolein** [d] | 5.91E-08 | 3.55E-05 | 1.06E-05 | 4.26E-05 |
| **Naphthalene** [e] | 9.75E-07 | 5.85E-04 | 1.76E-04 | 7.02E-04 |
| **Total PAH** [e, f] | 1.59E-06 | 9.54E-04 | 2.86E-04 | 1.14E-03 |
| *Greenhouse Gases* | | | | |
| **$CO_2$** [b] | 1.16 | 696 | 209 | 835 |
| **$CH_4$** [b, c] | 7.05E-04 | 0.423 | 0.127 | 0.508 |

a Emission factors for Tier II nonroad diesel engine emission standards from dieselnet.com ($NO_X$, CO, VOC and PM)
note - Tier II emission standards are not set for VOC (listed as Hydrocarbons), so the Tier I Standard is used
note - Tier II or Tier I emission standards are not set for $PM_{2.5}$, so the$PM_{10}$ emission factor is used

b AP-42 Volume I, Large Stationary Diesel Engines Tables 3.4-1 and 3.4-2 Diesel Fuel, 10/96
note - VOC emission factor represents total Hydrocarbon Emissions

c $CH_4$ Emission Factor listed in notes of AP-42 Table 3.4-1 as 9% of Total Organic Compounds

d AP-42 Volume I, Large Stationary Diesel Engines Table 3.4-3

e AP-42 Volume I, Large Stationary Diesel Engines Table 3.4-4

f PAH (Polycyclic Aromatic Hydrocarbons) includes naphthalene and are a HAP because they are polycyclic organic matter (POM)

# Road Construction Dust Emissions

**Assumptions:**

| | | |
|---|---|---|
| Hours of Construction | 4.00 | days per core hole (Estimate) |
| | 10.0 | hours/day |
| | 40.0 | hours per core hole Dozer |
| | 10.0 | hours per core hole pad Backhoe |
| Total Well Pads | 4 | core holes per year |
| Watering Control Efficiency | 50 | percent (Assumption) |
| Soil Moisture Content | 7.9 | percent (AP-42 Table 11.9-3, 7/98) |
| Soil Silt Content | 6.9 | percent (AP-42 Table 11.9-3, 7/98) |
| $PM_{10}$ Multiplier | 0.75 * $PM_{15}$ | (AP-42 Table 11.9-1, 7/98) |
| $PM_{2.5}$ Multiplier | 0.105 * TSP | (AP-42 Table 11.9-1, 7/98) |

**Equations:** From AP-42 tables 11.9-1 and 11.9-3 for Bulldozing Overburden Emissions, Western Surface Coal Mining, 10/98 & 7/98

Emissions (TSP lbs/hr) = $5.7 * (\text{soil silt content \%})^{1.2} * (\text{soil moisture content \%})^{-1.3} *$ Control Efficiency

Emissions ($PM_{15}$ lbs/hr) = $1.0 * (\text{soil silt content \%})^{1.5} * (\text{soil moisture content \%})^{-1.4} *$ Control Efficiency

**Emissions = 1.97 lbs TSP/hour/piece of equipment**

**Emissions = 0.50 lbs $PM_{15}$/hour/piece of equipment**

| | Dozer Emissions [a] | | | Backhoe Emissions [a] | | | Total |
|---|---|---|---|---|---|---|---|
| | lbs/hr | tons/hole | tons/yr [b] | lbs/hr | tons/hole | tons/yr [b] | tons/yr [b] |
| **TSP** | 1.97 | 0.0394 | 0.16 | 1.97 | 0.0099 | 0.04 | 0.20 |
| **$PM_{15}$** | 0.50 | 0.0100 | 0.04 | 0.50 | 0.0025 | 0.01 | 0.05 |
| **$PM_{10}$** | 0.38 | 0.0075 | 0.03 | 0.38 | 0.0019 | 0.01 | 0.04 |
| **$PM_{2.5}$** | 0.21 | 0.0041 | 0.02 | 0.21 | 0.0010 | 0.00 | 0.02 |

a Assumes one dozer and one backhoe. Backhoe emissions factors are conservatively estimated as equivalent to Dozer emissions.

b Assumes maximum development scenario

# Road Construction Grader Dust Emissions

**Assumptions:**

| | | |
|---|---|---|
| Grading Length | 4.13 | miles (1.375 miles/pad x 3 swaths (10' per swath)) |
| Hours of Construction | 4 | day grading per road segment (Estimate) |
| | 10 | hours/day |
| | 40 | hours per core hole |
| Total Well Pads | 4 | core holes per year |
| Watering Control Efficiency | 50 | percent (Assumption) |
| Average Grader Speed | 7.1 | mph (Typical value AP-42 Table 11.9-3, 7/98) |
| Distance Graded | 4.13 | miles (estimate) |
| $PM_{10}$ Multiplier | 0.6 * $PM_{15}$ | (AP-42 Table 11.9-1, 7/98) |
| $PM_{2.5}$ Multiplier | 0.031 * TSP | (AP-42 Table 11.9-1, 7/98) |

**Equations:** From AP-42 tables 11.9-1 and 11.9-3 for Bulldozing Overburden Emissions, Western Surface Coal Mining, 10/98

Emissions (TSP lbs) = $0.040 * (\text{Mean Vehicle Speed})^{2.5} *$ Distance Graded * Control Efficiency

Emissions ($PM_{15}$ lbs) = $0.051 * (\text{Mean Vehicle Speed})^{2.0} *$ Distance Graded * Control Efficiency

**Emissions = 11.08 lbs TSP/pad**

**Emissions = 5.30 lbs $PM_{15}$/pad**

| | Grader Construction Emissions | | | |
|---|---|---|---|---|
| | **lbs/pad** | **lbs/hr/pad** | **tons/pad** | **tons/yr [a]** |
| **TSP** | 11.08 | 0.28 | 5.54E-03 | 2.22E-02 |
| **$PM_{15}$** | 5.30 | 0.13 | 2.65E-03 | 1.06E-02 |
| **$PM_{10}$** | 3.18 | 0.08 | 1.59E-03 | 6.36E-03 |
| **$PM_{2.5}$** | 0.34 | 0.01 | 1.72E-04 | 6.87E-04 |

a Assumes maximum development scenario

# Core Hole Pad Construction Dust Emissions

**Assumptions:**

| | | |
|---|---|---|
| Hours of Construction | 4 | days per pad (Proposed Action) |
| | 10 | hours/day |
| | 40 | hours per pad Dozer |
| | 10 | hours per pad Backhoe |
| Total Well Pads | 4 | core holes per year |
| Watering Control Efficiency | 50 | percent (Assumption) |
| Soil Moisture Content | 7.9 | percent (AP-42 Table 11.9-3, 7/98) |
| Soil Silt Content | 6.9 | percent (AP-42 Table 11.9-3, 7/98) |
| $PM_{10}$ Multiplier | 0.75 * $PM_{15}$ | (AP-42 Table 11.9-1, 7/98) |
| $PM_{2.5}$ Multiplier | 0.105 * TSP | (AP-42 Table 11.9-1, 7/98) |

**Equations:** From AP-42 tables 11.9-1 and 11.9-3 for Bulldozing Overburden Emissions, Western Surface Coal Mining, 10/98

Emissions (TSP lbs/hr) = $5.7 * (\text{soil silt content \%})^{1.2} * (\text{soil moisture content \%})^{-1.3} *$ Control Efficiency

Emissions ($PM_{15}$ lbs/hr) = $1.0 * (\text{soil silt content \%})^{1.5} * (\text{soil moisture content \%})^{-1.4} *$ Control Efficiency

**Emissions = 1.97 lbs TSP/hour/piece of equipment**

**Emissions = 0.50 lbs $PM_{15}$/hour/piece of equipment**

| | Dozer Emissions [a] | | | Backhoe Emissions [a] | | | Total |
|---|---|---|---|---|---|---|---|
| | lbs/hr | tons/pad | tons/yr [b] | lbs/hr | tons/pad | tons/yr [b] | tons/yr [b] |
| **TSP** | 1.97 | 0.0394 | 0.16 | 1.97 | 0.0099 | 0.04 | 0.20 |
| **$PM_{15}$** | 0.50 | 0.0100 | 0.04 | 0.50 | 0.0025 | 0.01 | 0.05 |
| **$PM_{10}$** | 0.38 | 0.0075 | 0.03 | 0.38 | 0.0019 | 0.01 | 0.04 |
| **$PM_{2.5}$** | 0.21 | 0.0041 | 0.02 | 0.21 | 0.0010 | 0.00 | 0.02 |

a Assumes one dozer and one backhoe. Backhoe emissions factors are conservatively estimated as equivalent to Dozer emissions.

b Assumes maximum development scenario

# Core Hole Pad Construction Grader Dust Emissions

**Assumptions:**

| | | |
|---|---|---|
| Grading Length | 3.03 | miles on 400 ft x 400 ft pad |
| Hours of Construction | 4 | day grading per pad (Estimate) |
| | 10 | hours/day |
| | 40 | hours per pad |
| Total Pads | 4 | core holes per year |
| Watering Control Efficiency | 50 | percent (Assumption) |
| Average Grader Speed | 7.1 | mph (Typical value AP-42 Table 11.9-3, 7/98) |
| Distance Graded | 3.03 | miles |
| $PM_{10}$ Multiplier | 0.6 * $PM_{15}$ | (AP-42 Table 11.9-1, 7/98) |
| $PM_{2.5}$ Multiplier | 0.031 * TSP | (AP-42 Table 11.9-1, 7/98) |

**Equations:** From AP-42 tables 11.9-1 and 11.9-3 for Bulldozing Overburden Emissions, Western Surface Coal Mining, 10/98

Emissions (TSP lbs) = $0.040 * (\text{Mean Vehicle Speed})^{2.5} *$ Distance Graded * Control Efficiency

Emissions ($PM_{15}$ lbs) = $0.051 * (\text{Mean Vehicle Speed})^{2.0} *$ Distance Graded * Control Efficiency

**Emissions = 8.14 lbs TSP/well pad**

**Emissions = 3.90 lbs $PM_{15}$/well pad**

**Grader Construction Emissions**

| | lbs/pad | lbs/hr/pad | tons/pad | tons/yr [a] |
|---|---|---|---|---|
| **TSP** | 8.14 | 0.20 | 0.0041 | 0.02 |
| **$PM_{15}$** | 3.90 | 0.10 | 0.0019 | 0.01 |
| **$PM_{10}$** | 2.34 | 0.06 | 0.0012 | 0.00 |
| **$PM_{2.5}$** | 0.25 | 0.01 | 0.0001 | 0.001 |

a Assumes maximum development scenario

# Development Traffic Dust Emissions

Unpaved Calculation AP-42, Chapter 13.2.2
November 2006

$E\ (PM_{10}) / VMT = 1.5 * (S/12)^{0.9} * (W/3)^{0.45} * (365-p)/365)$
$E\ (PM_{2.5}) / VMT = 0.15 * (S/12)^{0.9} + (W/3)^{0.45} * (365-p)/365)$

| | | |
|---|---|---|
| Silt Content (S) | 8.5 | AP 42 13.2.2-1 Mean Silt Content Construction Sites |
| Round Trip Miles | 5 | Within project area |
| Precipitation Days (P) | 45 | days per year (NCDC data for Ouray, UT 1955-2004) |

Paved Calculation AP-42, Chapter 13.2.1
November 2006

$E\ (PM_{10}) / VMT = 0.016 * (sL/2)^{0.65} * (W/3)^{1.5} - 0.00047 * (1-(p/(365*4))$
$E\ (PM_{2.5}) / VMT = 0.0024 * (sL/2)^{0.65} * (W/3)^{1.5} - 0.00036 * (1-(p/(365*4))$

| | | |
|---|---|---|
| Silt Loading (sL) | 0.6 | AP-42 Table 13.2.1-3 baseline low volume roads |
| Round Trip Miles | 30 | From Moab (Estimated starting vehicle location) |
| Precipitation Days (P) | 45 | days per year |

W = average weight in tons of vehicles traveling the road

**Construction (days/hole and road)**

Hours per day 10
Days per hole 4

| Vehicle Type | Average Weight (lbs) | Round Trips per Core Hole | $PM_{10}$ (lb/VMT) | $PM_{10}$/Hole (lbs) | $PM_{10}$/Hole (lb/day) | $PM_{2.5}$/Hole (lbs) | $PM_{2.5}$/Hole (lb/day) |
|---|---|---|---|---|---|---|---|
| Haul Trucks: Equipment/Fuel | 80,000 | 3 | | | | | |
| Pickup Truck: Crew | 20,000 | 5 | | | | | |
| **Mean Vehicle Weight** | 42,500 | 8 | 2.33 | 93.1 | 23.3 | 9.3 | 2.3 |

**Unpaved Roads $PM_{10}$/Annual/core hole (tons)**: 0.047
**Unpaved Roads $PM_{2.5}$/Annual/core hole (tons)**: 0.005

| Paved: | $PM_{10}$ (lb/VMT) | $PM_{10}$/Pad (lbs) | $PM_{10}$/Pad (lb/day) | $PM_{2.5}$/Hole (lbs) | $PM_{2.5}$/Hole (lb/day) |
|---|---|---|---|---|---|
| | 0.133 | 32.0 | 8.0 | 4.7 | 1.2 |

$PM_{2.5}$ (lb/VMT): 0.020
**Paved Roads $PM_{10}$/Annual/core hole (tons)**: 0.016
**Paved Roads $PM_{2.5}$/Annual/core hole (tons)**: 0.002

**Drilling (days/core hole)**

Hours per day 24
Days per hole 35

| Vehicle Type | Average Weight (lbs) | Round Trips per Core Hole | $PM_{10}$ (lb/VMT) | $PM_{10}$/Hole (lbs) | $PM_{10}$/Hole (lb/day) | $PM_{2.5}$/Hole (lbs) | $PM_{2.5}$/Hole (lb/day) |
|---|---|---|---|---|---|---|---|
| Haul/Semi: Hvy Equip Hauler | 80,000 | 16 | | | | | |
| Logging/Mud Trucks | 70,000 | 8 | | | | | |
| Light Haul Trucks | 8,000 | 40 | | | | | |
| Water Trucks | 60,000 | 24 | | | | | |
| **Mean Vehicle Weight** | 40,909 | 88 | 2.29 | 1,006 | 29 | 101 | 2.9 |

**Unpaved Roads $PM_{10}$/Annual/core hole (tons)**: 0.503
**Unpaved Roads $PM_{2.5}$/Annual/core hole (tons)**: 0.050

| Paved: | $PM_{10}$ (lb/VMT) | $PM_{10}$/Pad (lbs) | $PM_{10}$/Pad (lb/day) | $PM_{2.5}$/Hole (lbs) | $PM_{2.5}$/Hole (lb/day) |
|---|---|---|---|---|---|
| | 0.126 | 332.0 | 9.5 | 49.1 | 1.4 |

$PM_{2.5}$ (lb/VMT): 0.019
**Paved Roads $PM_{10}$/Annual/core hole (tons)**: 0.166
**Paved Roads $PM_{2.5}$/Annual/core hole (tons)**: 0.025

**Interim Reclamation (days/core hole)**

Hours per day 10
Days per core hole 4

| Vehicle Type | Average Weight (lbs) | Round Trips per Core Hole | $PM_{10}$ (lb/VMT) | $PM_{10}$/Hole (lbs) | $PM_{10}$/Hole (lb/day) | $PM_{2.5}$/Hole (lbs) | $PM_{2.5}$/Hole (lb/day) |
|---|---|---|---|---|---|---|---|
| Haul/Semi: Hvy Equip Hauler | 80,000 | 3 | | | | | |
| Light Haul Trucks | 8,000 | 3 | | | | | |
| **Mean Vehicle Weight** | 44,000 | 6 | 2.36 | 70.9 | 17.7 | 7.1 | 1.8 |

**Unpaved Roads $PM_{10}$/Annual/core hole (tons)**: 0.035
**Unpaved Roads $PM_{2.5}$/Annual/core hole (tons)**: 0.004

| Paved: | $PM_{10}$ (lb/VMT) | $PM_{10}$/hole (lbs) | $PM_{10}$/hole (lb/day) | $PM_{2.5}$/Hole (lbs) | $PM_{2.5}$/Hole (lb/day) |
|---|---|---|---|---|---|
| | 0.140 | 25.3 | 6.3 | 3.7 | 0.9 |

$PM_{2.5}$ (lb/VMT): 0.021
**Paved Roads $PM_{10}$/Annual/core hole (tons)**: 0.013
**Paved Roads $PM_{2.5}$/Annual/core hole (tons)**: 0.002

**Annual Traffic Fugitive Dust Emissions (tons/year)**

Total core hole development: 4

**Total Unpaved Roads $PM_{10}$ (tons)**: **2.34**
**Total Unpaved Roads $PM_{2.5}$ (tons)**: **0.23**

**Total Paved Roads $PM_{10}$ (tons)**: **0.78**
**Total Paved Roads $PM_{2.5}$ (tons)**: **0.12**

# Construction Tailpipe Emissions

**Assumptions:**

| | | |
|---|---|---|
| Average Round Trip Distance | 35.0 | miles (Estimated from project area and existing road system) |
| Hours of Construction | 40 | hours per site (Proposed Action) |
| Number of Heavy Diesel Truck Trips | 3 | (Estimate) |
| Number of Pickup Trips | 36 | (Estimate) |
| Total number of pads | 4 | (Proposed Action) |
| Diesel Fuel sulfur content | 0.0005 | percent (Typical value) |
| Diesel Fuel density | 7.08 | lbs/gallon (Typical value) |
| Heavy Haul Diesel Fuel Efficiency | 10 | miles/gallon (Typical value) |
| Heavy Duty Pickup Fuel Efficiency | 15 | miles/gallon (Typical value) |

**Equations:**

For NOx, CO and VOC:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/mile)} * \text{\# Trips} * \text{Trip Distance (miles)}}{453.6\ \text{(g/lb)} * 2000\ \text{(lb/tons)}}$$

The NOx, CO and VOC emission factors for the above equation are from AP-42, while the $SO_2$ emissions are calculated on a mass balance basis utilizing the following equation:

$$SO_2\ \text{E. Factor (g/mi)} = \frac{\text{Fuel Density (lb/gal)} * 453.6\ \text{(g/lb)} * \text{Fuel Sulfur Content} * 2\ (S / SO_2)}{\text{Vehicle Fuel Efficiency (miles/gal)}}$$

| Construction Vehicles | Heavy Haul Trucks | | | Heavy Duty Pickups | | | Total [d] | |
|---|---|---|---|---|---|---|---|---|
| | E. Factor [a] (g/mile) | Emissions (lb/hr) | Emissions (tons/yr) | E. Factor [b] (g/mile) | Emissions (lb/hr) | Emissions (tons/yr/pad) | Emissions (lb/hr) | Emissions (tons/yr) |
| **NOx** | 8.13 | 0.047 | 0.001 | 3.23 | 0.224 | 0.004 | 0.271 | 0.022 |
| **CO** | 17.49 | 0.101 | 0.002 | 36.84 | 2.558 | 0.051 | 2.660 | 0.213 |
| **VOC** [c] | 4.83 | 0.028 | 0.001 | 2.29 | 0.159 | 0.003 | 0.187 | 0.015 |
| **$SO_2$** | 0.32 | 1.86E-03 | 3.72E-05 | 0.21 | 1.49E-02 | 2.97E-04 | 1.67E-02 | 0.001 |
| | | | | | | | | |
| **$CH_4$** [e, f] | 0.23 | 1.33E-03 | 2.66E-05 | 0.18 | 1.28E-02 | 2.56E-04 | 1.41E-02 | 1.13E-03 |

a AP-42 Table 7.1.2 - H.D. Diesel Powered Vehicles, High Altitude, 1991 - 1997 Model Year, 100,000 miles (6/95)
b AP-42 Table 4.1A.2 - H.D. Gasoline Vehicles, High Altitude, 1991 - 1997 Vehicle Year, 100,000 miles (6/95)
c Emission factor is for total Hydrocarbons.
d Assumes maximum development scenario
e AP-42 Table 7.10A.2 - Methane offsets for high altitude heavy duty diesel powered vehicle, 1988+
f AP-42 Table 4.10A.2 - Methane offsets for high altitude heavy duty gasoline powered vehicle, 1987+

# Heavy Equipment Construction Tailpipe Emissions

**Assumptions:**

| | | |
|---|---|---|
| Hours of Operation | 40 | hours/site (Proposed Action) |
| Development Rate | 4 | new pads per year (Proposed Action) |
| Load Factor | 0.4 | (Assumed typical value) |
| Backhoe miles per pad | 0.758 | miles (Value assumed to be 1/4 of dozer and grader mileage) |
| Backhoe Hours | 40 | hours per pad |
| Dozer miles per pad | 3.03 | miles (Based on 400 x 400 ft pad) |
| Dozer Hours | 40 | hours per pad |
| Grader miles per pad | 3.03 | miles (Based on 400 x 400 ft pad) |
| Motor Grader Hours | 40 | hours per pad |

**Equations:**

$$\text{Emissions (tons/year/pad)} = \frac{\text{Emission Factor (g/mile)} * \text{Trip Distance (miles)} * \text{Load Factor}}{453.6\ \text{(g/lb)} * 2000\ \text{(lb/tons)}}$$

| Heavy Const. Vehicles | Backhoe | | | Dozer | | | Grader | | |
|---|---|---|---|---|---|---|---|---|---|
| | E. Factor [a] (g/mile) | Emissions (lb/hr) | Emissions (tons/yr/pad) | E. Factor [a] (g/mile) | Emissions (lb/hr) | Emissions (tons/yr/pad) | E. Factor [a] (g/mile) | Emissions (lb/hr) | Emissions (tons/yr/pad) |
| **NOx** | 8.13 | 1.36E-04 | 2.72E-06 | 8.13 | 5.43E-04 | 1.09E-05 | 8.13 | 5.43E-04 | 1.09E-05 |
| **CO** | 17.49 | 2.92E-04 | 5.85E-06 | 17.49 | 1.17E-03 | 2.34E-05 | 17.49 | 1.17E-03 | 2.34E-05 |
| **VOC [b]** | 4.83 | 8.07E-05 | 1.61E-06 | 4.83 | 3.23E-04 | 6.45E-06 | 4.83 | 3.23E-04 | 6.45E-06 |
| | | | | | | | | | |
| **$CH_4$** | 0.23 | 3.84E-06 | 7.69E-08 | 0.23 | 1.54E-05 | 3.07E-07 | 0.23 | 1.54E-05 | 3.07E-07 |

| Heavy Const. Vehicles | Total | |
|---|---|---|
| | Emissions (lb/hr) | Emissions [c] (tons/yr) |
| **NOx** | 1.22E-03 | 9.78E-05 |
| **CO** | 2.63E-03 | 2.10E-04 |
| **VOC [d]** | 7.26E-04 | 5.81E-05 |
| | | |
| **$CH_4$** | 3.46E-05 | 2.77E-07 |

a AP-42 Table 7.1.2 - H.D. Diesel Powered Vehicles, High Altitude, 1991 - 1997 Model Year, 100,000 miles (6/95)
b Emission Factor represents total Hydrocarbon Emissions
c Assumes maximum development scenario
d AP-42 Table 7.10A.2 - Methane offsets for high altitude heavy duty diesel powered vehicle

# Drilling Tailpipe Emissions

**Assumptions:**

| | | |
|---|---|---|
| Average Round Trip Distance | 35.0 | miles (Estimated from project area and existing road system) |
| Hours of Operation | 840 | hours per site (Proposed Action) |
| Number of Heavy Diesel Truck Trips | 24 | (Estimate) |
| Number of Pickup Trips | 60 | (Estimate based on days drilling) |
| Total number of pads | 4 | (Proposed Action) |
| Diesel Fuel sulfur content | 0.0005 | percent (Typical value) |
| Diesel Fuel density | 7.08 | lbs/gallon (Typical value) |
| Heavy Haul Diesel Fuel Efficiency | 10 | miles/gallon (Typical value) |
| Heavy Duty Pickup Fuel Efficiency | 15 | miles/gallon (Typical value) |

**Equations:**

For NOx, CO and VOC:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/mile)} * \text{\# Trips} * \text{Trip Distance (miles)}}{453.6\ \text{(g/lb)} * 2000\ \text{(lb/tons)}}$$

The NOx, CO and VOC emission factors for the above equation are from AP-42, while the $SO_2$ emissions are calculated on a mass balance basis utilizing the following equation:

$$SO_2\ \text{E. Factor (g/mi)} = \frac{\text{Fuel Density (lb/gal)} * 453.6\ \text{(g/lb)} * \text{Fuel Sulfur Content} * 2\ (S / SO_2)}{\text{Vehicle Fuel Efficiency (miles/gal)}}$$

| Drilling Vehicles | Heavy Haul Trucks | | | Heavy Duty Pickups | | | Total [d] | |
|---|---|---|---|---|---|---|---|---|
| | E. Factor [a] (g/mile) | Emissions (lb/hr) | Emissions (tons/yr/hole) | E. Factor [b] (g/mile) | Emissions (lb/hr) | Emissions (tons/yr/hole) | Emissions (lb/hr) | Emissions (tons/yr) |
| **NOx** | 8.13 | 0.018 | 0.008 | 3.23 | 0.018 | 0.007 | 0.143 | 0.060 |
| **CO** | 17.5 | 0.039 | 0.016 | 36.8 | 0.20 | 0.085 | 0.966 | 0.406 |
| **VOC** [c] | 4.83 | 0.011 | 0.004 | 2.29 | 0.013 | 0.005 | 0.093 | 0.039 |
| **$SO_2$** | 0.321 | 7.08E-04 | 2.97E-04 | 0.214 | 1.18E-03 | 4.96E-04 | 7.55E-03 | 0.003 |
| | | | | | | | | |
| **$CH_4$** [e, f] | 0.230 | 5.07E-04 | 2.13E-04 | 0.180 | 9.92E-04 | 4.17E-04 | 6.00E-03 | 0.002 |

a AP-42 Table 7.1.2 - H.D. Diesel Powered Vehicles, High Altitude, 1991 - 1997 Model Year, 100,000 miles (6/95)
b AP-42 Table 4.1A.2 - H.D. Gasoline Vehicles, High Altitude, 1991 - 1997 Vehicle Year, 100,000 miles (6/95)
c Emission factor is for total Hydrocarbons.
d Assumes maximum development scenario
e AP-42 Table 7.10A.2 - Methane offsets for high altitude heavy duty diesel powered vehicle, 1988+
f AP-42 Table 4.10A.2 - Methane offsets for high altitude heavy duty gasoline powered vehicle, 1987+

# Completion Tailpipe Emissions

**Assumptions:**

| | | |
|---|---|---|
| Average Round Trip Distance | 35.0 | miles (Estimated from project area and existing road system) |
| Hours of Operation | 72 | hours per site (Proponent) |
| Number of Heavy Diesel Truck Trips | 49 | (Proponent) |
| Total number of pads | 4 | (Proposed Action) |
| Number of Pickup Trips | 63 | (Proponent) |
| Diesel Fuel sulfur content | 0.0005 | percent (Typical value) |
| Diesel Fuel density | 7.08 | lbs/gallon (Typical value) |
| Heavy Haul Diesel Fuel Efficiency | 10 | miles/gallon (Typical value) |
| Heavy Duty Pickup Fuel Efficiency | 15 | miles/gallon (Typical value) |

**Equations:**

For NOx, CO and VOC:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/mile)} * \text{\# Trips} * \text{Trip Distance (miles)}}{453.6\ \text{(g/lb)} * 2000\ \text{(lb/tons)}}$$

The NOx, CO and VOC emission factors for the above equation are from AP-42, while the $SO_2$ emissions are calculated on a mass balance basis utilizing the following equation:

$$SO_2\ \text{E. Factor (g/mi)} = \frac{\text{Fuel Density (lb/gal)} * 453.6\ \text{(g/lb)} * \text{Fuel Sulfur Content} * 2\ (S / SO_2)}{\text{Vehicle Fuel Efficiency (miles/gal)}}$$

| Completion Vehicles | Heavy Haul Trucks | | | Heavy Duty Pickups | | | Total [d] | |
|---|---|---|---|---|---|---|---|---|
| | E. Factor [a] (g/mile) | Emissions (lb/hr) | Emissions (tons/yr/pad) | E. Factor [b] (g/mile) | Emissions (lb/hr) | Emissions (tons/yr/pad) | Emissions (lb/hr) | Emissions (tons/yr) |
| **NOx** | 8.13 | 0.427 | 0.015 | 3.23 | 0.218 | 0.008 | 0.645 | 0.093 |
| **CO** | 17.49 | 0.918 | 0.033 | 36.84 | 2.487 | 0.090 | 3.406 | 0.490 |
| **VOC** [c] | 4.83 | 0.254 | 0.009 | 2.29 | 0.155 | 0.006 | 0.408 | 0.059 |
| **$SO_2$** | 0.32 | 1.69E-02 | 6.07E-04 | 0.21 | 1.45E-02 | 5.20E-04 | 3.13E-02 | 0.005 |
| | | | | | | | | |
| **$CH_4$** [e, f] | 0.23 | 1.21E-02 | 4.35E-04 | 0.18 | 1.22E-02 | 4.38E-04 | 2.42E-02 | 0.003 |

a AP-42 Table 7.1.2 - H.D. Diesel Powered Vehicles, High Altitude, 1991 - 1997 Model Year, 100,000 miles (6/95)
b AP-42 Table 4.1A.2 - H.D. Gasoline Vehicles, High Altitude, 1991 - 1997 Vehicle Year, 100,000 miles (6/95)
c Emission factor is for total Hydrocarbons.
d Assumes maximum development scenario
e AP-42 Table 7.10A.2 - Methane offsets for high altitude heavy duty diesel powered vehicle, 1988+
f AP-42 Table 4.10A.2 - Methane offsets for high altitude heavy duty gasoline powered vehicle, 1987+

# Interim Reclamation Tailpipe Emissions

**Assumptions:**

| | | |
|---|---|---|
| Average Round Trip Distance | 35.0 | miles (Estimated from project area and existing road system) |
| Hours of Operation | 40 | hours per site (Proponent) |
| Number of Heavy Diesel Truck Trips | 3 | (Assumption) |
| Number of Pickup Trips | 3 | (Assumption) |
| Total number of pads | 4 | (Proposed Action) |
| Diesel Fuel sulfur content | 0.0005 | percent (Typical value) |
| Diesel Fuel density | 7.08 | lbs/gallon (Typical value) |
| Heavy Haul Diesel Fuel Efficiency | 10 | miles/gallon (Typical value) |
| Heavy Duty Pickup Fuel Efficiency | 15 | miles/gallon (Typical value) |

**Equations:**

For NOx, CO and VOC:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/mile)} * \text{\# Trips} * \text{Trip Distance (miles)}}{453.6\ \text{(g/lb)} * 2000\ \text{(lb/tons)}}$$

The NOx, CO and VOC emission factors for the above equation are from AP-42, while the $SO_2$ emissions are calculated on a mass balance basis utilizing the following equation:

$$SO_2\ \text{E. Factor (g/mi)} = \frac{\text{Fuel Density (lb/gal)} * 453.6\ \text{(g/lb)} * \text{Fuel Sulfur Content} * 2\ (S / SO_2)}{\text{Vehicle Fuel Efficiency (miles/gal)}}$$

| Development Vehicles | Heavy Haul Trucks | | | Heavy Duty Pickups | | | Total [d] | |
|---|---|---|---|---|---|---|---|---|
| | E. Factor [a] (g/mile) | Emissions (lb/hr) | Emissions (tons/yr/pad) | E. Factor [b] (g/mile) | Emissions (lb/hr) | Emissions (tons/yr/pad) | Emissions (lb/hr) | Emissions (tons/yr) |
| **NOx** | 8.13 | 0.047 | 0.001 | 3.23 | 0.019 | 0.000 | 0.066 | 0.005 |
| **CO** | 17.49 | 0.101 | 0.002 | 36.84 | 0.213 | 0.004 | 0.314 | 0.025 |
| **VOC** [c] | 4.83 | 0.028 | 0.001 | 2.29 | 0.013 | 0.000 | 0.041 | 0.003 |
| **$SO_2$** | 0.32 | 1.86E-03 | 3.72E-05 | 0.21 | 1.24E-03 | 2.48E-05 | 3.10E-03 | 0.000 |
| | | | | | | | | |
| **$CH_4$** [e, f] | 0.23 | 1.33E-03 | 2.66E-05 | 0.18 | 1.04E-03 | 2.08E-05 | 2.37E-03 | 1.90E-04 |

a AP-42 Table 7.1.2 - H.D. Diesel Powered Vehicles, High Altitude, 1991 - 1997 Model Year, 100,000 miles (6/95)
b AP-42 Table 4.1A.2 - H.D. Gasoline Vehicles, High Altitude, 1991 - 1997 Vehicle Year, 100,000 miles (6/95)
c Emission factor is for total Hydrocarbons.
d Assumes maximum development scenario
e AP-42 Table 7.10A.2 - Methane offsets for high altitude heavy duty diesel powered vehicle, 1988+
f AP-42 Table 4.10A.2 - Methane offsets for high altitude heavy duty gasoline powered vehicle, 1987+

# Proposed Action Potential to Emit

**Assumptions:** Total emissions includes the drilling and reclamation of 4 core hole locations in a single year

| Species | Development Activity | | | |
|---|---|---|---|---|
| | **Drilling** | **Traffic Dust** | **Tailpipe** | **Total** |
| | **(tons/yr)** | **(tons/yr)** | **(tons/yr)** | **(tons/yr)** |
| *Criteria Pollutants & VOC* | | | | |
| **$NO_X$** | 10.944 | - | 0.18 | 11.124 |
| **CO** | 4.126 | - | 1.13 | 5.260 |
| **VOC** | 1.584 | - | 0.12 | 1.700 |
| **$PM_{10}$** | 0.288 | 3.21 | - | 3.494 |
| **$PM_{2.5}$** | 0.288 | 0.39 | - | 0.680 |
| **$SO_2$** | 2.91E-03 | - | 9.27E-03 | 0.012 |
| *Hazardous Air Pollutants* | | | | |
| **Benzene** | 4.19E-03 | - | - | 4.19E-03 |
| **Toluene** | 1.52E-03 | - | - | 1.52E-03 |
| **Xylenes** | 1.04E-03 | - | - | 1.04E-03 |
| **Formaldehyde** | 4.26E-04 | - | - | 4.26E-04 |
| **Acetaldehyde** | 1.36E-04 | - | - | 1.36E-04 |
| **Acrolein** | 4.26E-05 | - | - | 4.26E-05 |
| **Naphthalene** | 7.02E-04 | - | - | 7.02E-04 |
| **Total PAH** | 1.14E-03 | - | - | 1.14E-03 |
| *Greenhouse Gases* | | | | |
| **$CO_2$** | 835.20 | - | - | 835.20 |
| **$CH_4$** | 0.508 | - | 0.007 | 0.514 |